

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

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2

The following is a complete listing of all claims in the application, with an indication of the status of each:

Listing of claims:

- 1 1. (previously presented) A method of managing manufacturing logistics of
2 end products comprising the steps of:
3 maintaining an inventory of components, which components, termed
4 "building blocks", are built to stock, each said component having a cost;
5 configuring-to-order end products using said components;
6 establishing a base-stock level for each of said components; and
7 replenishing said components from suppliers in accordance with said
8 base-stock levels so as to reduce a total cost of inventory of said components,
9 wherein said cost of at least one component differs from said cost of at
10 least one other component, and wherein said difference determines the result
11 of said replenishing step.
- 1 2. (original) The method of managing manufacturing logistics of end
2 products recited in claim 1, wherein the end products are personal computers
3 (PCs) and the components are stock computer components.
- 1 3. (original) The method of managing manufacturing logistics of end
2 products recited in claim 1, wherein the base-stock levels are derived from a
3 greedy algorithm which iteratively reduces inventory budget until a budget
4 constraint is satisfied.

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

3

- 1 4. (previously presented) A computer implemented process of managing
 2 manufacturing logistics of configure-to-order end products comprising the
 3 steps of:
- 4 a) initializing a process of managing manufacturing logistics of
 5 configure-to-order end products by setting $x_i := 0$ for each $i \in S$, setting $r_{mi} :=$
 6 $P(X_{mi} > 0)$, setting $\beta_m := 0$ for each $m \in M$, and setting $\beta := 0$, where S is a set
 7 of components indexed by i , M is a set of end products indexed by m , x_i is a
 8 probability of no-stockout of a component of index i , r_{mi} is a probability that
 9 a positive number of units of component i is used in the assembly of an end
 10 product indexed by m , β_m is a probability of stockout of an end product of
 11 index m , and β is an upper limit on the stockout probability over all end
 12 products;
- 13 b) setting a set of active components to $A := \{\}$;
- 14 c) considering each $i \in S$, followed by considering each end product m
 15 that uses component i in its bill-of-material;
- 16 d) setting $\beta_m := \beta_m + r_{mi} \Delta$, for all m such that $i \in S_m$ where Δ is a unit
 17 step size;
- 18 e) computing the a difference $\delta_i := \max_m \{\beta_m\} - \beta$;
- 19 f) determining if $\delta_i \leq 0$, and if so, then adding component index i to the
 20 set of active components, $A := A + \{i\}$;
- 21 g) determining if the set of active components is non-empty, and if so,
 22 then setting $B := A$, otherwise setting $B := S$ where B is a set of component
 23 indexes;
- 24 h) finding $i^* := \arg \max_{i \in B} \{-c_i \sigma_i / r_{mi} g'(x_i + \Delta/2)\}$, where $-g'(\cdot)$ follows
 25 the equation $-g'(x) = -\Phi(\bar{\Phi}^{-1}(x)) \cdot \frac{-1}{\Phi(\bar{\Phi}^{-1}(x))} = \frac{1-x}{\Phi(\bar{\Phi}^{-1}(x))}$, where $\Phi(\cdot)$ is a

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

4

26 probability distribution function of the standard normal variate, and $\phi(\cdot)$ is a
 27 probability density function of the standard normal variate;

28 i) setting $x_i^* := x_i^* + \Delta$ to update the probability of no-stockout of
 29 component i^* ;

30 j) computing $\beta := \max_{m \in M} \beta_m$, and checking whether inequality
 31 $\sum_{i \in S} c_i \phi_g(x_i) \leq B$, where B is the budget limit on the expected overall

32 inventory cost, is satisfied and if so, stop and replenish components identified
 33 by said set B from suppliers following a base-stock policy that minimizes a
 34 total cost of inventory of said components i ,

35 wherein said cost c_i of at least one component differs from said cost
 36 c_i of at least one other component ;

37 k) otherwise, updating β_m and for each $m \in M$, set $\beta_m := \beta_m + r_m \Delta$, and
 38 going to step b).

1 5. (previously presented) A system for managing manufacturing logistics of
 2 end products comprising:

3 means for maintaining an inventory of components, which
 4 components, termed "building blocks", are built to stock, each said component
 5 having a cost;

6 means for configuring-to-order end products using said components;

7 means for establishing a base-stock level for each of said components;

8 and

9 means for replenishing said components from suppliers in accordance
 10 with said base-stock levels so as to minimize a total cost of inventory of said
 11 components,

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION** 00280619aa
 Amendment dated 09/13/2004 Reply to office action mailed 07/13/2004

5

12 wherein said cost of at least one component differs from said cost of at
 13 least one other component, and wherein said difference determines the result
 14 produced by said replenishing means.

1 6. (original) The system for managing manufacturing logistics of end
 2 products recited in claim 5, wherein the end products are personal computers
 3 (PCs) and the components are stock computer components.

1 7. (original) The system for managing manufacturing logistics of end
 2 products recited in claim 5, wherein the base-stock levels are derived from a
 3 greedy algorithm which is iteratively computed by a processing unit to reduce
 4 inventory budget until a budget constraint is satisfied.

1 8. (previously presented) A method that translates end-product demand
 2 forecast in an assemble-to-order (ATO) environment into a forecast for
 3 components, taking into account outbound leadtime comprising the steps of:
 4 defining in an assemble-to-order (ATO) environment an end product
 5 demand $D_m(t)$ of type m in period t , each unit of type m demand requiring a
 6 subset of components, denoted $S_m \subseteq S$, as

7
$$D_i(t) = \sum_{m \in M_i} D_m(t + L_m^{\text{out}}); \text{ [and]}$$

8 deriving mean and variance for component demand $D_i(t)$ as

9
$$E[D_i(t)] = \sum_{m \in M_i} \sum_l E[D_m(t+l)]P[L_m^{\text{out}}=l], \text{ and}$$

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

6

$$\text{Var}[D_i(t)] = \sum_{m \in M_i} \sum_t E[D_m^2(t+\ell)] P[L_m^{\text{out}} = \ell] - \sum_{m \in M_i} \left(\sum_t E[D_m(t+\ell)] P[L_m^{\text{out}} = \ell] \right)^2, \text{ respectively; and}$$

11 replenishing said components from suppliers following a base stock
 12 policy that minimizes a total cost of inventory of said components, each said
 13 component having a cost,
 14 wherein said cost of at least one component differs from said cost of at
 15 least one other component, and wherein said difference determines the result
 16 of said replenishing step.

1 9. (original) The method recited in claim 8, wherein the ATO environment is
 2 extended to a configure-to-order (CTO) environment for stationary demand,
 3 taking into account batch sizes comprising the steps of:
 4 translating end-product demand into demand for each component i (per
 5 period) as

$$D_i = \sum_{m \in M_i} \sum_{k=1}^{D_m} X_{mi}(k).$$

7 where $X_{mi}(k)$, for $k = 1, 2, \dots$, are independent, identically distributed (i.i.d.)
 8 copies of X_{mi} ;
 9 deriving marginal distributions, and then the mean and the variance of
 10 X_{mi} as

$$E[D_i] = \sum_{m \in M_i} E[X_{mi}] E[D_m], \text{ and}$$

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

7

$$\begin{aligned} \text{Var}[D_i] &= \sum_{m \in M_i} \left(E[D_m] \text{Var}[X_{mi}] + \text{Var}[D_m] E^2[X_{mi}] \right) \\ &= \sum_{m \in M_i} \left(E^2[X_{mi}] E[D_m^2] + \text{Var}[X_{mi}] E[D_m] - E^2[X_{mi}] E^2[D_m] \right), \text{ respectively.} \end{aligned}$$

10. (original) The method recited in claim 9, extended to non-stationary demand, wherein the mean and the variance of X_{mi} are generalized as

$$E[D_i(t)] = \sum_{m \in M_i} E[X_{mi}] \sum_l E[D_m(t+l)] P[L_m^{\text{out}} = l], \text{ and}$$

$$\begin{aligned} \text{Var}[D_i(t)] &= \sum_{m \in M_i} E^2(X_{mi}) \sum_l E[D_m^2(t+l)] P[L_m^{\text{out}} = l] \\ &\quad + \sum_{m \in M_i} \text{Var}(X_{mi}) \sum_l E[D_m(t+l)] P[L_m^{\text{out}} = l] \\ &\quad - \sum_{m \in M_i} E^2(X_{mi}) \left(\sum_l E[D_m(t+l)] P[L_m^{\text{out}} = l] \right)^2, \text{ respectively.} \end{aligned}$$

11. (previously presented) The method recited in claim 9, further comprising the steps of:

defining $R_i(t)$ as a reorder point (or, base-stock level) in period t as

$$R_i(t) := \mu_i(t) + k_i(t) \sigma_i(t),$$

where $k_i(t)$ is a desired safety factor, while $\mu_i(t)$ and $\sigma_i(t)$ can be derived (via queuing analysis) as

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

8

$$\mu_i(t) = \sum_{s=t}^{\ell_i^{\text{in}}-1} E[D_i(s)], \text{ and}$$

$$\sigma_i^2(t) = \sum_{s=t}^{\ell_i^{\text{in}}-1} \text{Var}[D_i(s)], \text{ respectively,}$$

where $\ell_i^{\text{in}} := E[L_i^{\text{in}}]$ is expected in-bound leadtime; and

translating $R_i(t)$ into "days of supply" (DOS), where the $\mu_i(t)$ part of $R_i(t)$ translates into periods of demand and the $k_i(t)\sigma_i(t)$ part of $R_i(t)$ is turned into

$$\frac{k_i(t)\sigma_i(t)}{\frac{\mu_i(t)}{\ell_i^{\text{in}}}}$$

periods of demand so that $R_i(t)$ is expressed in terms of periods of DOS as

$$\text{DOS}_i(t) = \ell_i^{\text{in}} \left[1 + k_i(t) \frac{\sigma_i(t)}{\mu_i(t)} \right].$$

12. (original) The method recited in claim 11, wherein demand is stationary in which for each demand class m , $D_m(t)$ is invariant in distribution over time, so that the mean and the variance of demand per period for each component i reduce to

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**
 Amendment dated 09/13/2004

00280619aa

Reply to office action mailed 07/13/2004

9

5 $\mu_i = \ell_i^{\text{in}} E[D_i]$, and $\sigma_i^2 = \ell_i^{\text{in}} \text{Var}[D_i]$, respectively, and

6 $R_i = \ell_i^{\text{in}} E[D_i] + k_i \sqrt{\ell_i^{\text{in}}} \text{sd}[D_i]$, and hence,

7
$$\text{DOS}_i = \frac{R_i}{E[D_i]} = \ell_i^{\text{in}} + k_i \theta_i \sqrt{\ell_i^{\text{in}}} = \ell_i^{\text{in}} \left[1 + k_i \frac{\theta_i}{\sqrt{\ell_i^{\text{in}}}} \right],$$

8 where $\theta_i := \text{sd}[D_i]/E[D_i]$ is the coefficient of variation of the demand *per*
 9 *period* for component i , and hence $\theta_i / \sqrt{\ell_i^{\text{in}}}$ is the coefficient of variation of the
 10 demand over the leadtime ℓ_i^{in} .

1 13. (previously presented) A method that relates service requirements to
 2 base-stock levels of components in an assemble-to-order (ATO) environment
 3 comprising the steps of:
 4 defining in an assemble-to-order (ATO) environment each order of
 5 type m as requiring exactly one unit of component $i \in S_m$, α as a required
 6 service level, referred to as off-shelf availability of all the components
 7 required to configure a unit of type m product, for any m , and E_i as an event
 8 that component i is out of stock;
 9 determining a probability P for each end product $m \in M$,

10
$$P[\cup_{i \in S_m} E_i] \leq 1 - \alpha, \text{ and}$$

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**
 Amendment dated 09/13/2004

00280619aa

Reply to office action mailed 07/13/2004

10

$$11 \quad P[\cup_{i \in S_m} E_i] = \sum_i P(E_i) - \sum_{i < j} P(E_i \cap E_j) + \sum_{i < j < k} P(E_i \cap E_j \cap E_k) - \dots, \text{ and}$$

$$12 \quad P[\cup_{i \in S_m} E_i] = \sum_{i \in S_m} P(E_i) = \sum_{i \in S_m} \bar{\Phi}(k_i) \leq 1 - \alpha; \text{ and}$$

13 establishing base stock levels for each component i that minimize a
 14 total cost of inventory of said components, each said component having a cost,
 15 wherein said cost of at least one component differs from said cost of at
 16 least one other component, and wherein said difference determines the result
 17 of said step of establishing base stock levels.

1 14. (previously presented) The method recited in 13, wherein the method is
 2 extended to a configure-to-order (CTO) environment taking into account batch
 3 sizes, further comprising the steps of:

4 defining $A \subset S_m$ as a certain configuration, which occurs in a demand
 5 stream with probability $P(A)$;
 6 weighting a no-stockout probability, $\prod_{i \in A} \Phi(k_i)$, by $P(A)$;
 7 changing the service requirement to

$$\begin{aligned} \alpha &\leq \sum_{A \subset S_m} P(A) \prod_{i \in A} \Phi(k_i) \\ &= \sum_{A \subset S_m} P(A) [1 - \sum_{i \in A} \bar{\Phi}(k_i)] \\ 8 \quad &= 1 - \sum_{A \subset S_m} P(A) \sum_{i \in A} \bar{\Phi}(k_i) \\ &= 1 - \sum_{i \in S_m} \left(\sum_{A \ni i} P(A) \right) \bar{\Phi}(k_i); \text{ and} \end{aligned}$$

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION** 00280619aa
 Amendment dated 09/13/2004 Reply to office action mailed 07/13/2004

11

9 extending the CTO environment the service requirement to

10
$$\sum_{i \in S_m} r_{mi} \bar{\Phi}(k_i) \leq 1 - \alpha$$

11 where r_{mi} is the probability that a positive number of units of component i is
 12 used in the assembly of an end product indexed by m .

1 15. (previously presented) A method that translates service requirements in
 2 terms of leadtimes into requirements for off-shelf availability of components
 3 comprising the steps of:

4 relating an off-shelf availability requirement to standard customer
 5 service requirements expressed in terms of leadtimes, W_m , where a required
 6 service level of type m demand is

7
$$P[W_m \leq w_m] \geq \alpha, \quad m \in M,$$

8 where w_m 's are given data and P is probability;

9 when there is no stockout at any store $i \in S_m$, denoting the associated
 10 probability as $\pi_{0m}(i)$, a delay being L_i^{out} , the out-bound leadtime;

11 when there is a stockout at one or several stores in the subset $s \subseteq S_m$,
 12 denoting the associated probability as $\pi_{sm}(i)$, so that the delay becomes
 13 $L_i^{\text{out}} + \tau_s$, where τ_s is the additional delay before the missing components in s
 14 become available;

15 determining $P[W_m \leq w_m] = \pi_{0m}(i)P[L_m^{\text{out}} \leq w_m] + \sum_{s \in S_m} \pi_{sm}(i)P[L_m^{\text{out}} + \tau_s \leq w_m]$;

YOR9-2000-0041 **AFTER FINAL: EXPEDITED ACTION**

00280619aa

Amendment dated 09/13/2004

Reply to office action mailed 07/13/2004

12

16 assuming that

17 $L_m^{\text{out}} \leq w_m$ and $L_m^{\text{out}} + T_s > w_m$

18 both hold *almost surely*, so that when the (nominal) outbound leadtime is
19 nearly deterministic and shorter than what customers require, whereas the
20 replenish leadtime for any component is substantially longer; and
21 replenishing said components from suppliers following a base stock
22 policy that minimizes a total cost of inventory of said components, each said
23 component having a cost,
24 wherein said cost of at least one component differs from said cost of at
25 least one other component, and wherein said difference determines the result
26 of said replenishing step.

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